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2002 Characterization Trials for Fixed Wing and Rotor Wing Aircraft Using *Bacillus thuringiensis*

Wheeler, Michigan
October 9-13, 2001

Clewiston, Florida
January 30 - February 3, 2002

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Introduction

For several years there have been discrepancies between various state and federal agencies concerning assigned swath widths for various aircraft used for gypsy moth control projects. Different agencies have characterized spray aircraft and have often assigned swath widths based on a single card line's result using various estimates of what constitutes efficacious deposit. Historically, USDA-APHIS guidelines (USDA-APHIS 1996) have been used as a basis for assigning swath widths. However, these swaths were developed using flat fan nozzles and water. The criteria used for determining the effective swath widths are not known. Work by Teske et al. (1990), Ghent and Twardus (1994), and Ghent and Onken (1994) have shown that swath widths recommended in these guidelines often differ significantly from field characterization trials and spray deposition models.

The variation in assigned swaths between government agencies has lead to confusion in contract bidding and a redundancy of calibration and characterization of aircraft. Aerial application contractors are often unsure of what swath width to use to calculate their contract bid and frequently must repeatedly demonstrate acceptable swath widths through characterization trials as they move from one state to another.

To reduce variation and establish uniform swath widths, characterization trials were conducted in 2000 (Ghent and Onken 2001) to determine the effective swath width for the Air Tractor 502, Turbine Thrush, Dromader (M-18), and Turbine Ag-Cat. In this report the criteria for defining adequate deposition used to determine effective swath width was established for all aircraft using *Bacillus thuringiensis* var. *kurstaki* (*Btk*) at an application rate of 0.5 gal/acre

Additional trials to determine swath widths for lower volume – higher potency *Btk* formulations, atomizer placement on the boom, and helicopters have since been requested. To address these questions, trials were held in the fall in Michigan and in the winter in Florida. This paper documents the results of these studies.

Objective

Determine the effective swath of the Air Tractor 502, Turbine Thrush, M-18, HU-1H (military version of the Bell 205A), and OH-58 (military version of the Bell 206) with undiluted *Btk*. Application rates of 0.33 gal/acre (25 BIU/Ac) for fixed wing, and rates of 0.5 and 0.33 gal/acre for rotor wing were tested.

Methods

FIXED WING - Michigan

During the week of October 9, 2001, characterization trials were performed at Earl's Spraying Service in Wheeler, Michigan. The trial objectives were: 1) Evaluate swath width of the M-18 (Dromader) at 0.5 gal/ac; 2) determine effective swath widths for AT 502, Turbo Thrush, and M-18 for 0.33 gal/ac; 3) evaluate atomizer placement along the boom to reduce coefficient of variation across the spray pattern.

Each aircraft was equipped with Micronair AU5000 atomizers. Each aircraft was calibrated for an application rate of 0.33 gal/ac (25 BIU/ac using a 76 BIU formulation) at each assigned swath width tested. In addition, the M-18 was calibrated at 0.50 gal/ac (24 BIU/ac using a 48 BIU formulation). Spray booms were removed from the aircraft and each Micronair unit was calibrated using Michigan Department of Agriculture's portable calibration tank (figure 1). Blade angles were set at 35 degrees to give smallest droplet size (100 µm). Micronair placement along the boom was measured from the aircraft center to the center of the atomizer mount.

Figure 1. Spray boom calibration tank.

ROTOR WING – Florida

During the week of January 29, 2002, characterization trials were performed at Helicopter Applicators in Clewiston, Florida. The trial objectives were: Evaluate swath width for HU-1H and OH-58.

Both helicopters were equipped with Micronair AU5000 atomizers with extended blades; with 6 on the OH-58 and 8 on the UH-1H. Each aircraft was calibrated for both 0.5 and 0.33 gal/ac for each of the assigned swath widths tested. Micronair blade angles were set at 45 degrees. Micronair placement along the boom was measured from the aircraft center to the center of the atomizer mount.

Both field trials were carried out over a large flat recently mowed field. For each flight, a one thousand foot card line was established perpendicular to the aircraft's flight path. The direction of the card line was dependent on wind direction. If wind direction varied more than 15 degrees from perpendicular to the line, a new card line was established. Spray deposit was collected on 2 inch by 3 inch Kromekote cards spaced 10 feet apart (figure 2). Cards were placed at a 45 degree angle, into the wind, on card stands approximately 10 inches above the ground. Red dye was added to the Foray to provide a dark stain for image analysis.

Each trial consisted of three flight lines spaced at the assigned swath width. Each of the three flight lines was marked using three white plastic buckets, spaced at the assigned swath width, parallel to the aircraft's flight line. All spray runs were made at a height of 35 to 50 feet above the card line. Three replicates for each aircraft and swath width were conducted.

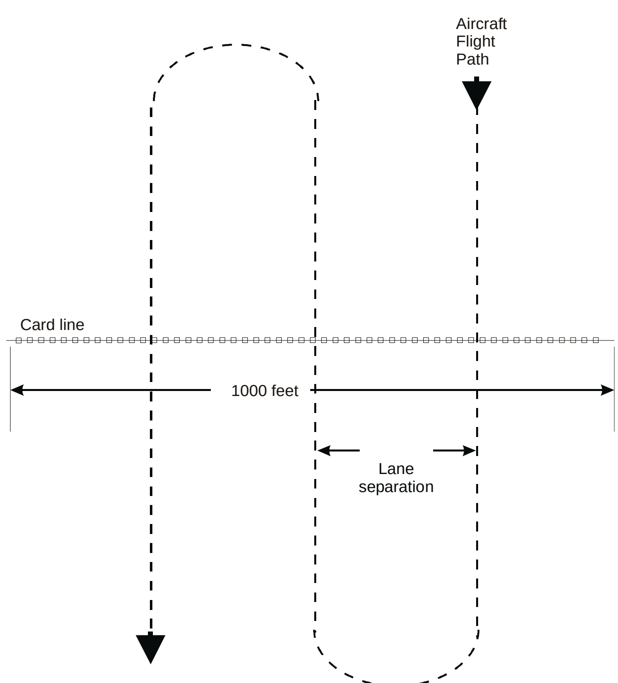

Figure 2. Layout of cardline and aircraft flight path for characterization trial.

Wind speed, wind direction, air temperature and relative humidity were recorded for each spray trial.

Five minutes after the last pass over the card line, cards were collected and placed in slide boxes. SwathKit for Windows (Droplet Technologies) was used to determine droplet size, volume, and density for each card. Each card recorded average deposition in drops/cm^2, VMD (Volume Median Diameter), and NMD (Number Median Diameter).

Data Analysis

The use of commercial formulations of *Btk* to control gypsy moth populations is widespread in the eastern U.S. Approximately 91% of the treated forested acres were aerially sprayed with *Btk* during the 2000 gypsy moth cooperative suppression projects. A typical application is made undiluted at a rate of 24 BIU/ac at the application volume of 0.5 gal/ac. In recent years, high potency *Btk* formulations (76 BIU) have been used at application rates of 25 to 36 BIU/acre, at an application volume of 0.33 or 0.5 gal/acre, respectively.

Canopy deposition studies of the application rate of 0.5 gal/ac have shown forest canopy droplet densities ranging from 0.5 to 10 drops/cm^2 on foliage (Mierzejewski et al. 1993, Dubois et al. 1993, van Frankenhuyzen et al. 1991). Droplet sizes during these applications can range from 28 to 640 µm depending on the atomizer used. Studies using Micronair rotary atomizers have indicated a variety of recovered droplet sizes with approximate VMD of 180 µm (Bryant and Yendol 1988), 100 µm (Mierzejewski et al. 1993), and 120-140 µm (van Frankenhuyzen et al. 1991). Variation in size and density can result from environmental conditions during application, changing rotation speed of the rotary atomizer, and application rates. Although several field studies have attempted to determine the optimal droplet size for *Btk*, no clear conclusions were obtained. In addition, since atmospheric conditions greatly influence the final size of the deposited droplet on foliage, it is difficult to estimate the actual dose contained within the measure droplet.

Determining Dose

A laboratory study by Maczuga and Mierzejewski (1995) was conducted to determine the toxicity of undiluted *Btk* when applied to 2^{nd}, 3^{rd}, and 4^{th} instar gypsy moth larvae with droplet size and density comparable to those of aerial applications. Although late 1^{st} and early 2^{nd} instar life stages are the target for program managers to begin treatment, some late 3^{rd} and 4^{th} instars are usually present, especially during multiple applications (e.g. eradication projects).

Results show that droplet densities of 5 to 10 cm^2 for all three-droplet sizes were effective against 2^{nd} instars (100% mortality) (Table 1). Bryant and Yendol (1988) also reported higher gypsy moth mortality for doses in droplets 50-150 µm than from droplets > 150 µm.

Table 1. Percentage of mortality of gypsy moth larvae when exposed for 6 days to different droplet densities and sizes of Foray 48B

		Instar		
Droplet Size (µm)	Drops/cm^2	2^{nd}	3^{rd}	4^{th}
100	1	56	43	23
	5	100	80	47
	10	100	97	73
200	1	87	72	50
	5	100	98	87
	10	100	100	100
300	1	97	87	60
	5	100	100	97
	10	100	100	100
Control	10	3	0	

Also, droplets of 100 µm had lower Lethal Time (in hours) for 95% larval mortality (LT_{95}) values than 200 to 300 µm droplets at droplet densities of 5 to 10 drops/cm^2 (Table 2).

Table 2. Lethal Time (in hours) for 95% larval mortality

Droplet Size (µm)	Drops/cm²	Instar 2nd	3rd	4th
100	1	767	613	471
	5	87	188	449
	10	59	126	236
200	1	243	196	265
	5	107	125	183
	10	56	91	102
300	1	166	211	299
	5	52	114	149
	10	102	123	122

The LT_{95} values obtained also show that 2nd instars are killed more quickly than 3rd or 4th instars at equal droplet densities.

Exposure

When comparing droplet potency by droplet size, the 76 BIU formulation has 60% more IU's per volume than the same size droplet of 48 BIU material (Figure 3). By reducing the droplet size of 76 BIU

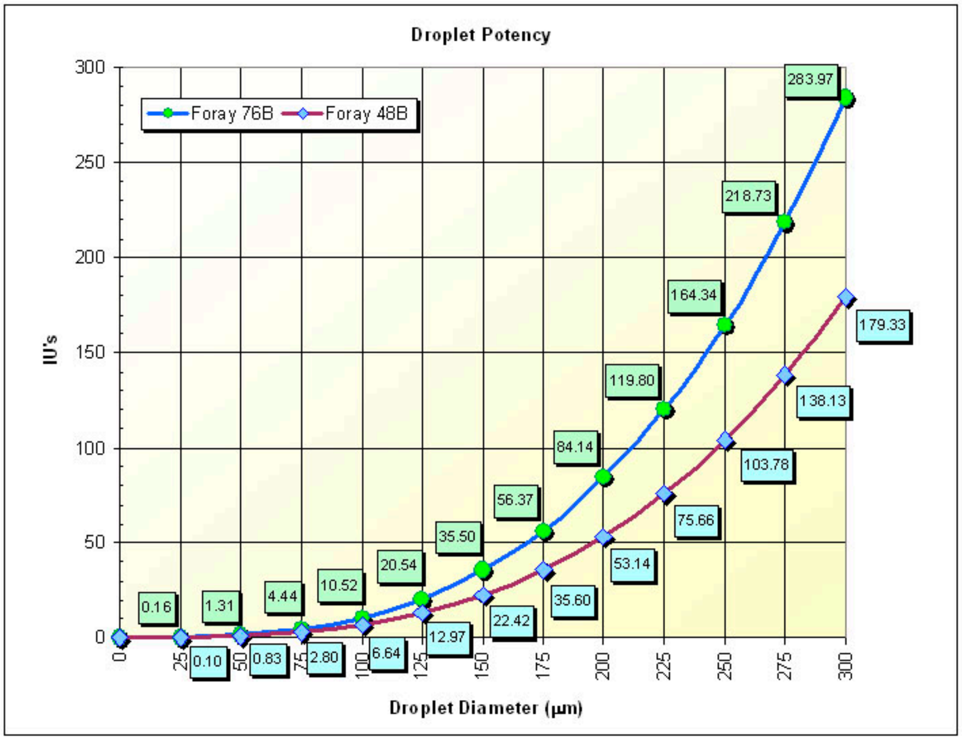

Figure 3. Droplet potency as expressed in the number of IU per droplet size for two formulations of Foray. Note that the average dose in the 150 µm droplet of 48B is equivalent to that of a 125 µm droplet of Foray 76B, 22.42 and 20.54 IU's respectively.

material from 150 µm to 125 µm, approximately two billion more droplets would be produced with similar potency (Figure 4).

If *Btk* were applied at a rate of 0.5 gal/ac, with a uniform droplet size of 200 µm or 100 µm to the surface of one acre and 100 percent recovery of deposit was assumed, it would result in a deposit of 11.8 or 94.4 drops/cm², respectively. In reality, deposition, droplet size, and droplet density are not uniform. The forest offers a multitude of deposit surfaces besides the desired leaf. These include twigs,

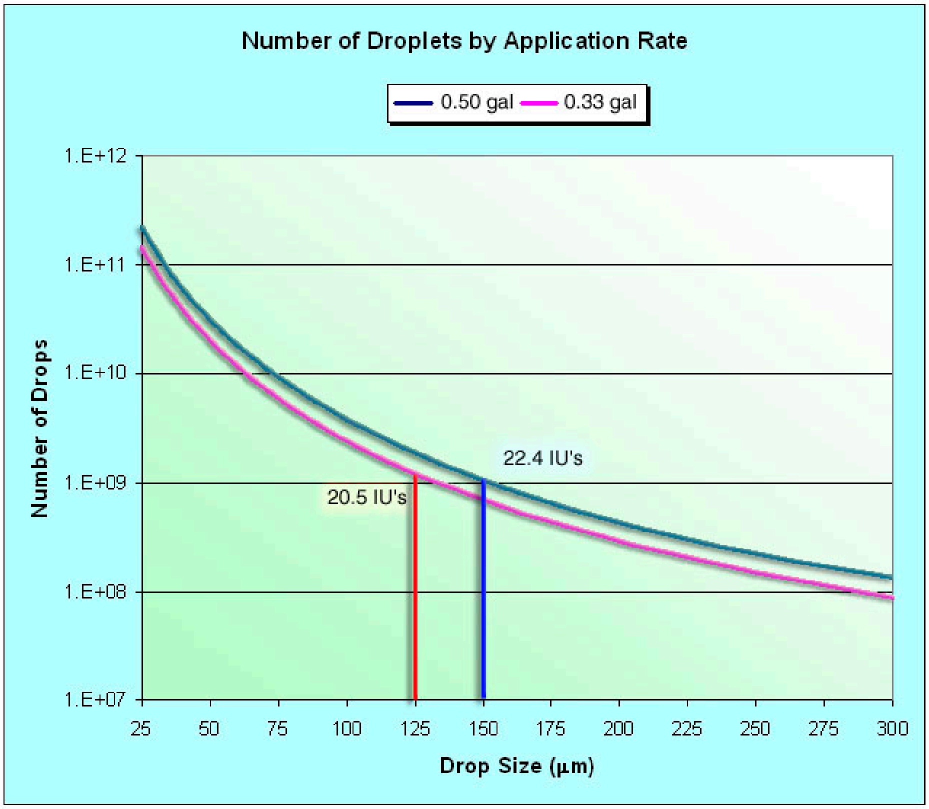

Figure 4. Assuming uniform generation of droplets, the calculated number of droplets by size produced by two different application volumes. Note that the lower volume rate (0.33 gal/ac) produces more droplets of approximate potency than with the higher volume rate.

branches, and tree boles. All these surfaces receive some portion of the aircraft's spray cloud. For example, a single tree with a 12 inch dbh at a height of 50 feet has a bole surface area of approximately 118,000 cm^2. It is estimated that for every acre of forest floor, there will be between 3 to 5 acres of foliage surface area.

A spray cloud resulting from an application rate of 0.5 gal/ac, assuming 100 percent recovery, would result in a deposit of between 3.9 (11.8 drops/cm^2 divided by 3 acres of foliage surface area) to 2.4 (11.8 drops/cm^2 divided by 5 acres of foliage surface area) drops/cm^2 for uniform 200 µm droplets. For uniform 100 µm droplets, between 31.5 to 18.8 drops/cm^2 would be produced. During field applications of *Btk*, droplets produced are not uniform in size with the majority (NMD) being less than half the size of the VMD.

Getting droplets to the target foliage is difficult. Less than half of the droplets released are deposited on foliage. Dubois et al. (1993) showed that an application rate of 0.75 gal/ac of *Btk* resulted in only 53% of the foliage having droplet densities greater than 5 drops/cm^2 and an overall VMD of 103 microns. Bryant et al. (1987) measured the fate of a *Btk* application in a hardwood forest and found up to 45 percent of the spray released was not accounted for by foliar or ground deposit. On average more droplets were deposited in the upper crown, than in the middle crown, which had more than the lower. The smaller the VMD, the more uniform the coverage appears throughout the canopy (van Frankenhuyzen et al. 1991; Mierzejewski et al. 1993).

Effective Swath Width = Dose (IUs) + Exposure (Number of Drops/cm^2)

Based on the results from the feeding study conducted by Maczuga and Mierzejewski (1995), second instar gypsy moth larvae may be more effectively controlled at the standard 24 BIU/ac application rate using an average droplet size of 100 microns at 5 drops/cm^2. For this evaluation to

achieve this density on leaves, a droplet density of between 15 (5 drops/cm^2 x 3 acres of foliage surface) to 25 (5 drops/cm^2 x 5 acres of foliage surface) drops/cm^2 with a droplet size between 100-200 μm would be used to evaluate the effective swath width of each aircraft.

COV is defined as the samples standard deviation expressed as a percentage of the mean. It is a relative measure of variability in the data. Teske et al. (1990) used a COV of 30 percent to establish an acceptable swath based on work by Parkin and Wyatt (1982). A high COV would indicate a high variation in deposit across the card line. It must be remembered that for effective control, it is the deposited dose and not the variation of deposit that is important. As long as the deposit exceeds the established effective threshold, in this case 20 drops/cm^2, of 100 to 200 μm droplets, then an effective dose is present. The high COV does however indicate that portions of the swath width may be receiving excessive deposit.

In an attempt to reduce the high COV recorded in previous trials, the effect of atomizer placement on the boom was evaluated.

For effective control, both the dose of the droplet and the probability of encounter by gypsy moth larvae are considered. For these studies, effective swath width for an aircraft must meet two criteria. First, a coverage of at least twenty drops/cm^2; second, droplet sizes as expressed by the VMD of the deposit, must be between 100 and 200 μm for Foray 48B formulations, and 80 and 125 μm for Foray 76B formulations. This should provide an effective dose and probability of encounter for gypsy moth control when using undiluted *Btk* formulations with either 48 or 76 BIU's per gallon.

Deposit for each spray run was plotted for both drops/cm^2 and VMD. Arrows included in the graphs mark the targeted lane separation and indicate the direction of flight. The primary reason for using cumulative flight path deposits was to get a truer picture of the additive effects of overall deposit from adjacent flight lines. As the flight lines are moved further apart, the effects of overlapping deposit will diminish and gaps where insufficient deposition occurs are apparent.

Michigan Results

M-18

The M-18 was assigned a swath width of 150 feet following spray trials conducted in 2001 (Ghent and Onken 2001). Attempts to achieve 200 foot swath width did not yield sufficient coverage to be acceptable.

The M-18 was setup with eight AU5000 Micronairs with blade angles set at 45 degrees. Atomizers were positioned at 5.8, 13.8, 19.5, and 26.3 feet with the outer most unit at 90.5% of the 58 foot wing-span.

Trials were also run using hydraulic nozzles fitted with 8010 flat fan atomizers. Atomizers were evenly spaced along the boom to 90% of wingspan to compare deposition with that from Micronairs.

Figures 5 and 6 show deposition patterns for Micronair and flat fan atomizers for a 175 foot swath width at 0.5 gal/ac application rate.

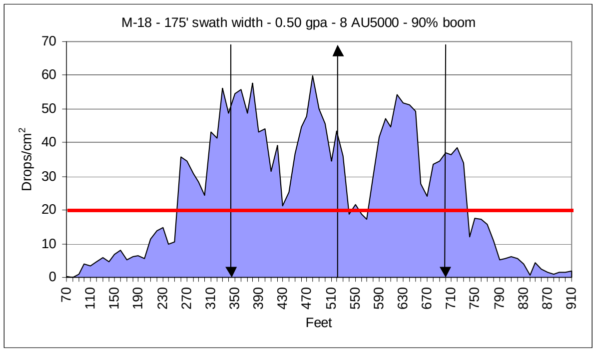

Figure 5. Deposition pattern from M-18 using AU5000 Micronair atomizers at 175 foot swath width.

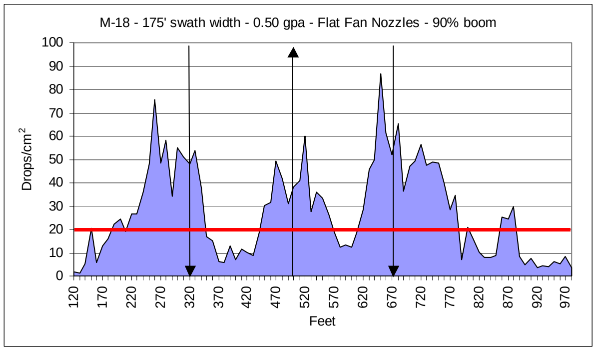

Figure 6. Deposition pattern from M-18 using 8010 flatfan atomizers at 175 foot swath width.

The deposit pattern from flat fan atomizers did not achieve the effective deposit density of 20 drops/cm^2 across the card line. This is probably due to the larger VMD produced by flatfat atomizers than achieved with Micronairs. Even a slight increase in the spray's VMD can significantly reduce the number of droplets produced.

Air Tractor 502

The Air Tractor 502 was calibrated for a 150 foot swath width and was equipped with six AU5000 Micronair atomizers and Ag-Tip winglets. Micronairs were positioned at 8.0, 16.0, and 23.5 feet from the aircraft center line, with outer most atomizers set at 95% of the 48 foot wingspan. The atomizers blade

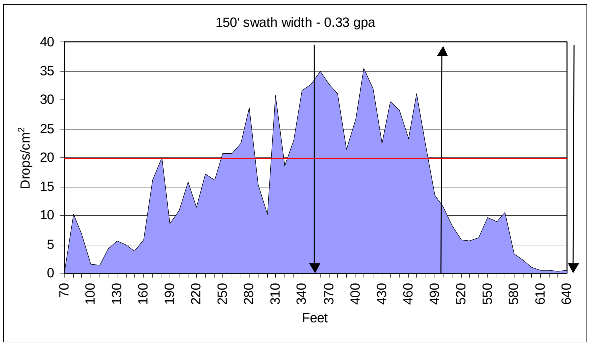

Figure 7. Deposition pattern in drops/cm^2 for Air Tractor 502 for 0.33 gal/ac application rate.

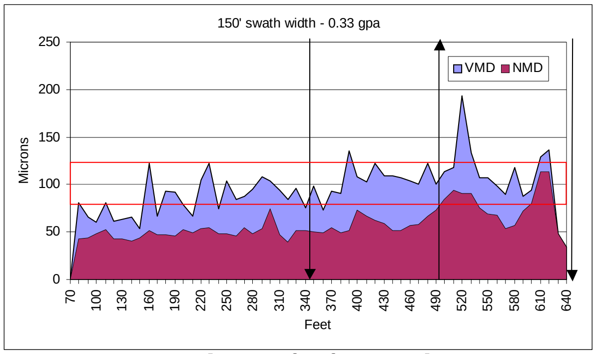

Figure 8. VMD and NMD for figure 7 deposit at 0.33 gal/ac application rate.

angles were set at 45 degrees for an application rate of 0.33 gal/ac. Figure 7 shows the deposition pattern based on number of drops and figure 8 plots the droplet size NMD and VMD for a 150 foot swath width.

The deposition pattern met the requirements of 20 drops/cm^2 and stayed within the 80 to 125 VMD droplet spectrum. For this run there was a slight crosswind which moved the pattern approximately 1 swath width to the left.

Positioning Atomizers

In an earlier characterization trial (Ghent and Onken 2001), locating the outer most atomizers at the end of the wing span showed improved deposition of droplets across the card line. To further evaluate atomizer positioning, the AT 502 positioned all the Micronairs to the outer portion of the wing span. The atomizer were repositioned at 16, 20.5, and 23.3 feet from aircraft center line so that all atomizers were on the outer third (66%) of the wing span (Figure 9).

Figures 10 through 15 show a comparison between the two atomizer setup for the AT 502. Graphs on the left are for evenly spaced atomizers across the wing span, those on the right are for atomizers grouped on the outer third of the wing span.

Figure 9. Air Tractor 502 configured with Micronair AU5000's on the outer third of the wing span.

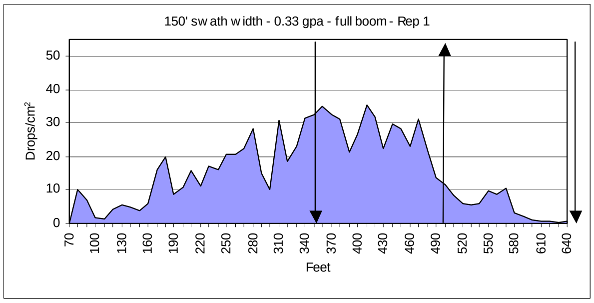

Figure 10. Deposition pattern for AT-502 with 6 atomizers distributed across wing span.

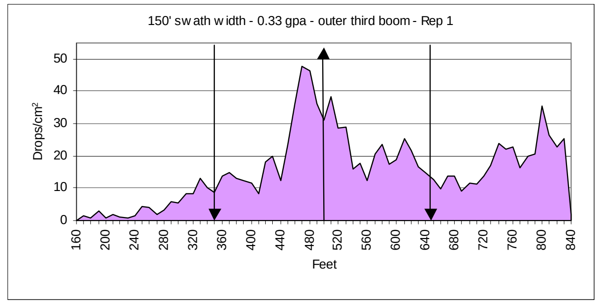

Figure 11. Deposition pattern for AT-502 with 6 atomizers located at outer third of wing span.

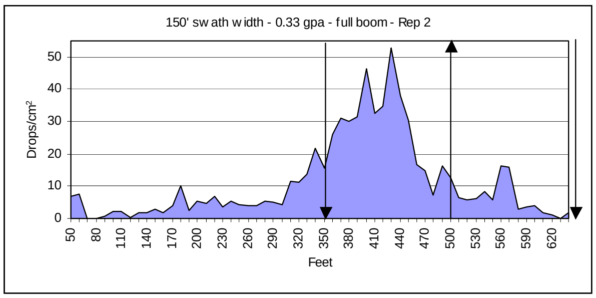

Figure 12. Deposition pattern for AT-502 with 6 atomizers distributed across wing span.

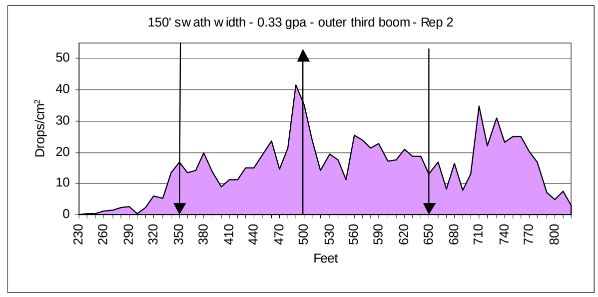

Figure 13. Deposition pattern for AT-502 with 6 atomizers located at outer third of wing span.

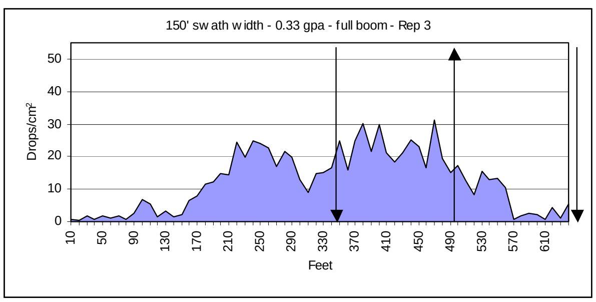

Figure 14. Deposition pattern for AT-502 with 6 atomizers distributed across wing span.

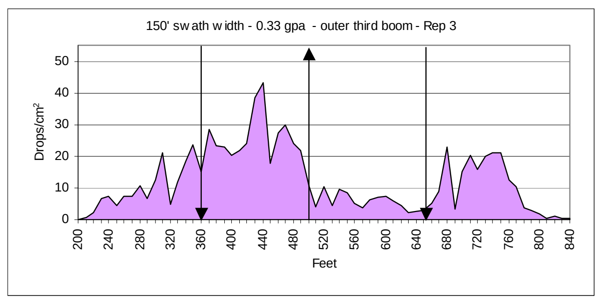

Figure 15. Deposition pattern for AT-502 with 6 atomizers located at outer third of wing span.

There was no significant difference in the average COV between full wing (44.5) and outer-third wing (49.3) setups. The average amount of deposition between setups were also similar with 20 drop/cm^2 for the full wing and 18 drops/cm^2 for the outer-third wing. The biggest difference was in the increased spread of the spray pattern across the entire card line. Looking at a 10 drop/cm^2 deposit threshold, the average coverage for the full wing was 330 feet and for the outer-third wing was 477 feet. This would indicate that more droplets were deposited in the outer-third wing setup.

The vortices created by the wing-tips trail behind the aircraft and capture the droplets as the vortex moves through the settling spray material. These vortices create the noticeable deposit peaks that we are familiar within deposit graphs. Because the effect caused by the vortices is determined by the vortice's strength and droplet size, droplets smaller than 100 µm are easily captured by the vortices. Depending on the aircraft height, these vortices can actually assist to bring small drops down faster. Typical ag-aircraft vortices have sink velocities of 0.3-0.5 m/s, up to ten times faster than the settling speeds of small droplets. By moving the atomizers to the outer wing where the vortices are the strongest, the small droplets are quickly captured by the vortex and better controlled and therefore less likely to drift.

Aryes Turbo Thrush

The Turbo Thrush was calibrate for a 150 foot swath width and was equipped with 8 Micronairs located at 9.0, 12.8, 16.6, and 19.5 feet along the wing as measured from the aircraft center line. The outer most atomizer was located at 81 percent of the 48 foot wing span. Figures 16 shows deposition in drops/cm^2 and figure 17 graphs the spray's VMD and NMD.

For the 0.33 gal/ac application rate, deposition and droplet size met the criteria for effective deposit at 150 foot swath width.

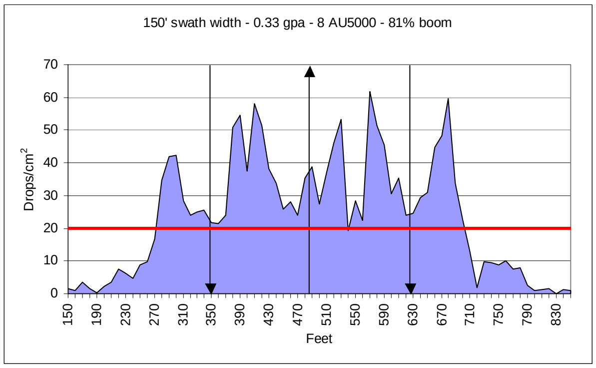

Figure 16. Deposition pattern in drops/cm^2 for the Turbo Thrush at 0.33 gal/ac application rate.

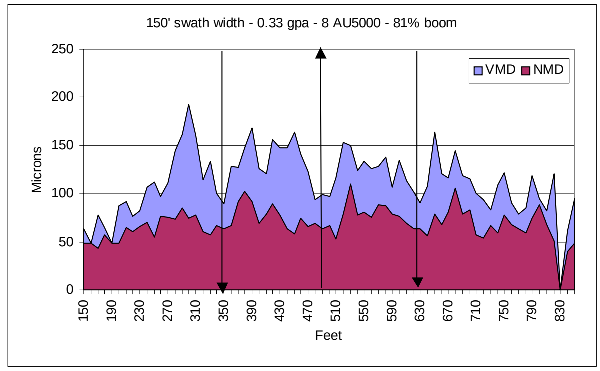

Figure 17. VMD and NMD for figure 16 deposit at 0.33 gal/ac application rate.

Positioning Atomizers

The Turbo Thrush was used to evaluate the deposition patterns from individual atomizers located on the boom. Trials were conducted with only two of the eight atomizers operating per card line. One atomizer on each wing located at equal distance from the aircraft center line were paired. The outer most Micronairs - 1 and 8 were located at 19.5 feet, Micronairs - 2 and 7 were located at 16.6 feet, Micronairs - 3 and 6 were located at 12.8 feet, and Micronairs - 4 and 5 were located at 9.0 feet. All trials were at the same 150 swath width.

Figures 18 - 20 show deposition patterns for each replicate of atomizer pairs 1 and 8.

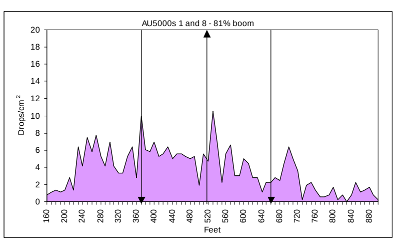

Figure 18. Atomizer pair 1 and 8 deposition, run 1.

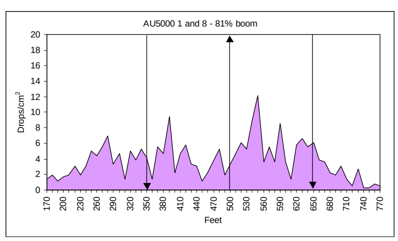

Figure 19. Atomizer pair 1 and 8 deposition, run 2.

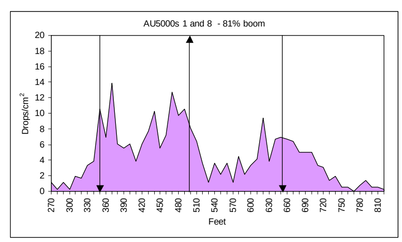

Figure 20. Atomizer pair 1 and 8 deposition,run 3.

Figures 21 - 23 show deposition patterns from each replicate of atomizer pair 2 and 7.

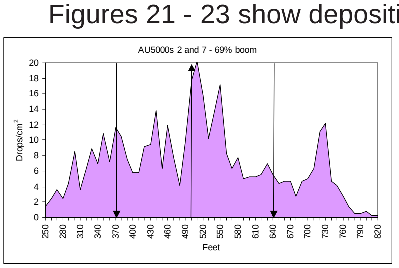

Figure 21. Atomizer pair 2 and 7 deposition, run 1.

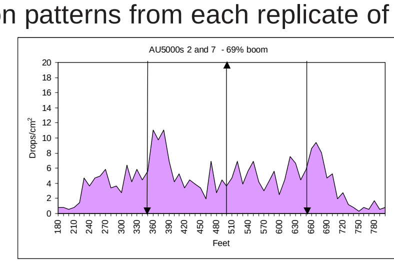

Figure 22. Atomizer pair 2 and 7 deposition, run 2.

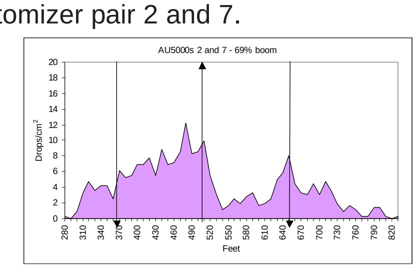

Figure 23. Atomizer pair 2 and 7 deposition, run 3.

Figures 24 - 26 show deposition patterns from each replicate of atomizer pair 3 and 6.

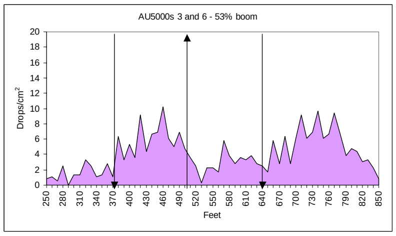

Figure 24. Atomizer pair 3 and 6 deposition, run 1

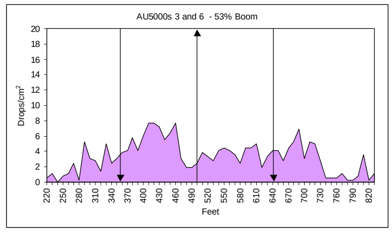

Figure 25. Atomizer pair 3 and 6 deposition, run 2

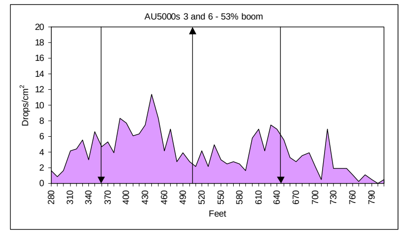

Figure 26. Atomizer pair 1 and 8 deposition, run 3

Figures 27 - 39 show deposition patterns from each replicate of atomizer pair 4 and 5.

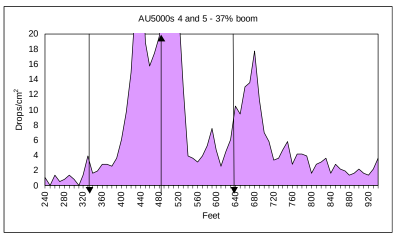

Figure 27. Atomizer pair 4 and 5 deposition, run 1

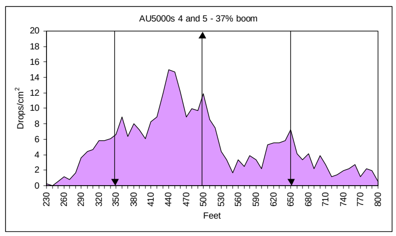

Figure 28. Atomizer pair 4 and 5 deposition, run 2

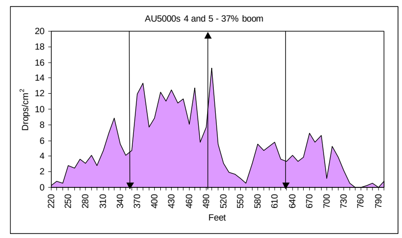

Figure 29. Atomizer apair 4 and 5 deposition, run 3

Table 1. COV for each of the trial runs.

Atomzer Pair	COV			Average
	Run 1	Run 2	Run 3	
1 & 8	30	48	50	43
2 & 7	49	40	51	47
3 &6	48	42	47	46
4 & 5	75	51	62	63

When viewed collectively, only the atomizer pairs of 4 and 5 show noticeable differences in overall deposit (see Table 1). This pair also had the highest recorded COV of 75 and the highest average of 63. The high COV appears to be the result of a high concentrated spray deposition with a low amount of lateral movement from these peaks. This would suggest that the spray cloud is being concentrated and held together by the aircraft vortex until deposition.

Figure 30 shows vertices being formed behind a turbo thrush. It shows that individual vortices are formed from each atomizer's spray. In this picture the aircraft has only 6 Micronairs. The inner most pair of atomizers has a vortex formed lower and later than those located at the mid and end

Figure 30. Vorticies for each of six Micronairs forming behind the Turbo Thrush.

wing. This may account for the high peak formed from the most interior set of atomizers. The small drops released from these atomizers are captured by the weaken vortex trailing behind the aircraft. This vortex does not have enough energy for lateral dispersion of the droplets as do the stronger vortices formed at the wing ends.

Further work is needed to determine the best location for atomizers along the wing.

Florida Results

The Florida characterization trials were held in Clewiston, Florida from January 29 through February 3, 2002. Two helicopters were characterized, the UH-1H Iroquois (the military version of the Bell 205A-1) and the OH-58 (the military version of the Bell 206B-III). Card line setup and interpretation of effective deposition were the same as the 2001 Michigan trial (Ghent and Onken 2001).

OH-58 (Bell 206B-III)

The OH-58 has a larger rotor diameter than the standard Bell 206B-III, at 35.6 feet versus 33.33 feet, respectively. This larger diameter will likely account for a wider deposition pattern, but probably not significantly different from the standard Bell 206B. The helicopter was outfitted with 6 AU5000 Micronairs, positioned at 5.75, 9.5, and 13.5 feet. Figures 31 - 36 show deposition patterns based on droplet sizes for 75, 100, and 125 foot swath widths. All runs were calibrated for and an applicaton of 0.5 gal/ac.

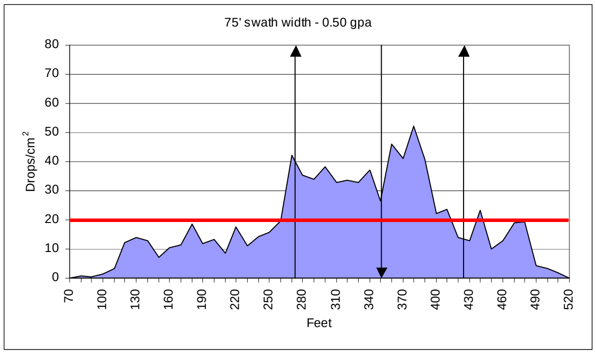

Figure 31. Deposition pattern for OH-58 at 75 foot swath width for 0.5 gal/ac application rate.

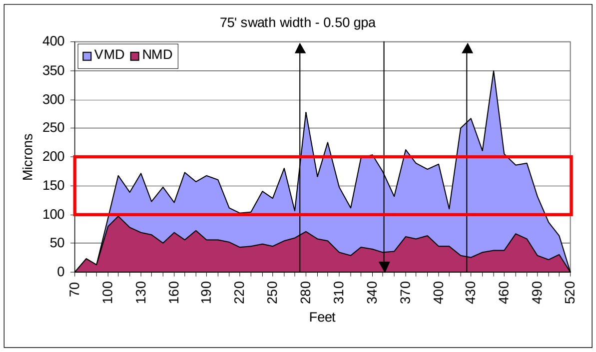

Figure 32. VMD and NMD for deposition infigure 31.

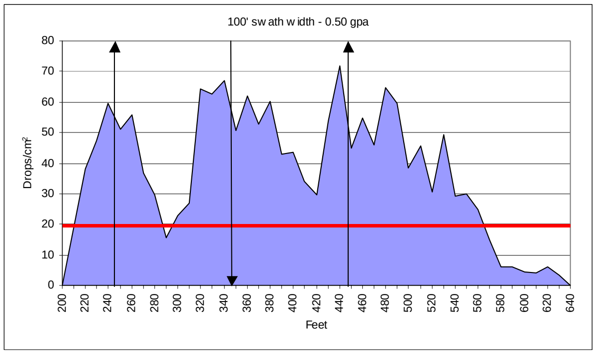

Figure 33. Deposition pattern for OH-58 at 100 foot swath width for 0.5 gal/ac application rate.

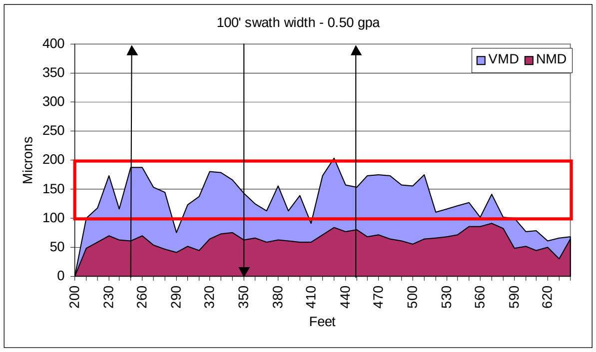

Figure 34. VMD and NMD for deposition in figure 33.

The deposition pattern and droplet size distribution for 75 and 100 foot lane separation showed sufficient coverage to be acceptable. Note, that for the 100 foot lane separation, the areas of low deposition between flight lines are beginning to form, as evident by the valleys between high deposition peaks.

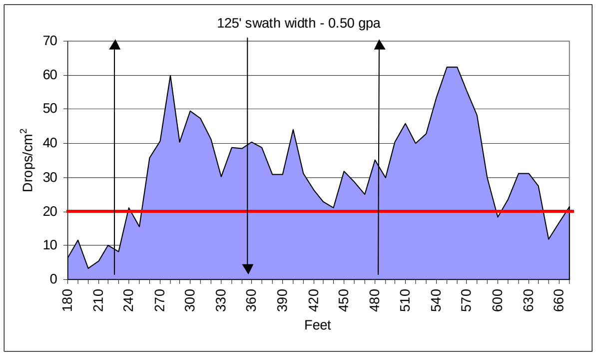

Figure 35. Deposition pattern for OH-58 at 125 foot swath width for 0.5 gal/ac application rate.

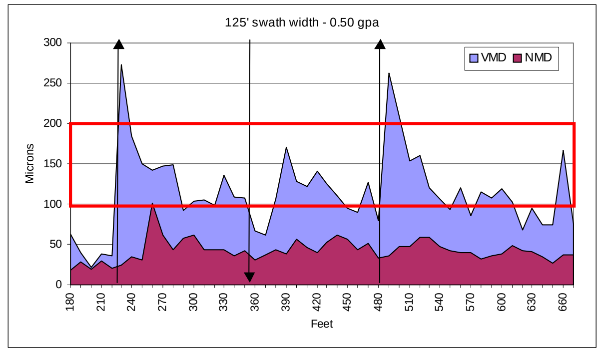

Figure 36. VMD and NMD for deposition in figure 35.

All of the spray runs conducted for a 125 foot lane separation had some amount of crosswind. The number of droplets per square centimeter was above the line, but droplets size fell below acceptable levels for dose. The effect of the cross wind aided in filling in the gaps present between flight lines, but these drops were too small in size and did not contain sufficient IU's for effective control.

In addition to the 0.5 gal/ac rate, the OH-58 was calibrated and characterized for 0.33 gal/ac to simulate high potency *Btk* formulations. Figure 37 and 38 give the deposition and droplet size results at a 100 foot lane separation. The drop density and drop size spectrum meet the criteria for effective swath width.

For the OH-58 and Bell 206B III, the recommended maximum swath width for both 0.33 and 0.5 gal/ac application rate is 100 feet.

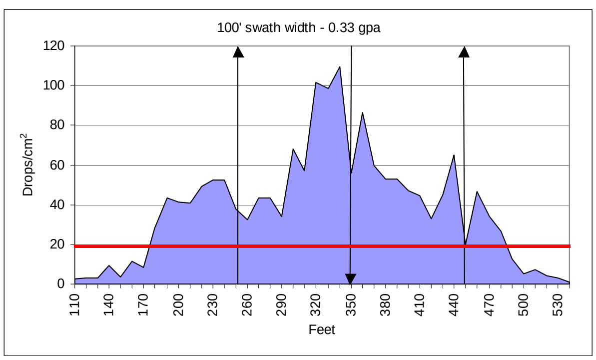

Figure 37. Deposition pattern for OH-58 at 100 foot swath width for 0.33 gal/ac application rate.

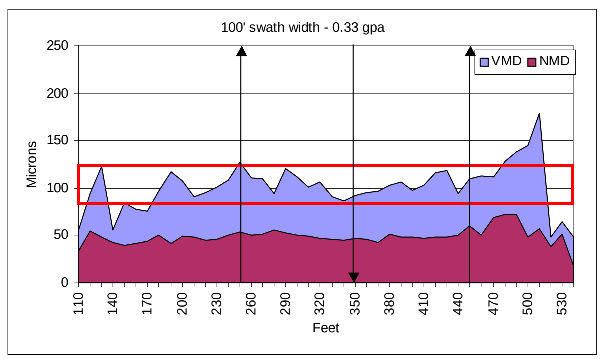

Figure 38. VMD and NMD for depostion in figure 37.

HU-1H (Bell 205A-1)

The HU-1H was evaluated at three different swath widths: 125, 150 and 175 feet at the 0.5 gal/ac application rate. The helicopter was fitted with 8 AU5000 Micronairs located at: 8.75, 13.0, 17.75, and 22.6 feet along the boom. Figures 39 through 45 show the deposition and drop sizes for each of the different swath widths.

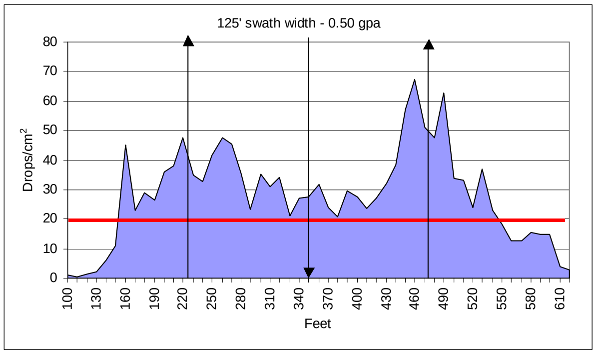

Figure 39. Deposition pattern for UH-1H at 125 foot swath width for 0.5 gal/ac application rate.

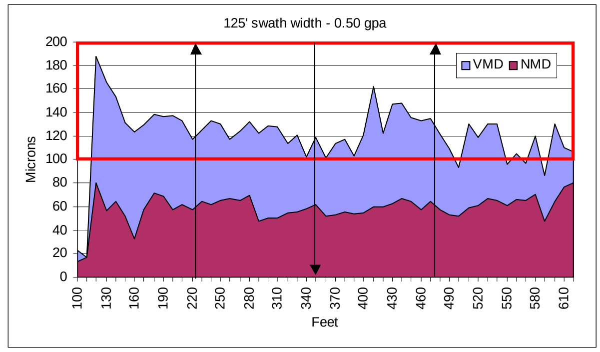

Figure 40. VMD and NMD for depostion in figure 39.

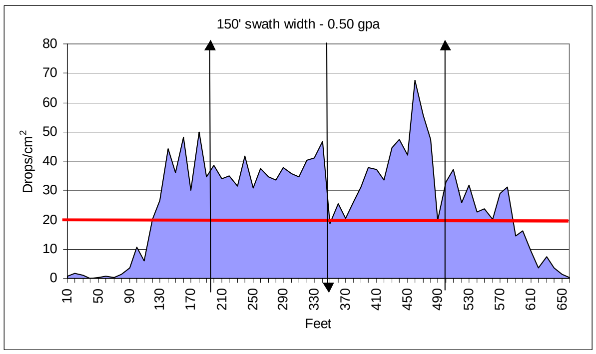

Figure 41. Deposition pattern for UH-1H at 150 foot swath width for 0.5 gal/ac application rate.

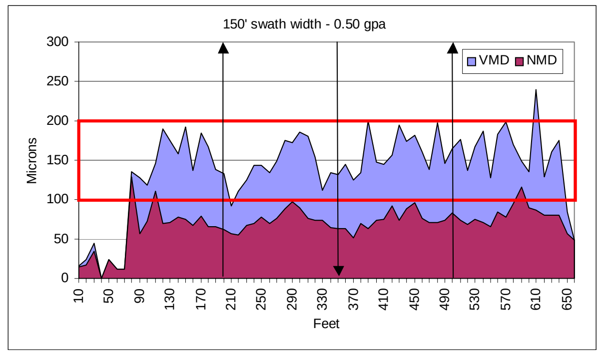

Figure 42. VMD and NMD for deposition in figure 41.

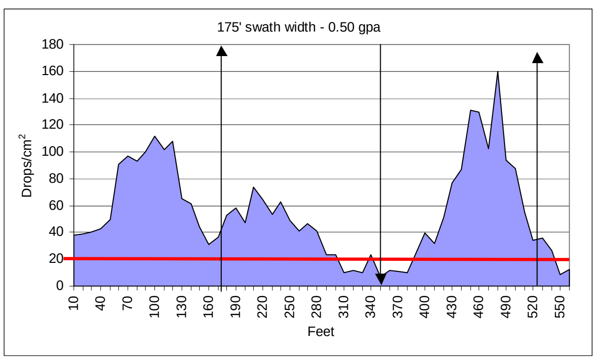

Figure 43. Deposition pattern for UH-1H at 175 foot swath width for 0.5 gal/ac application rate

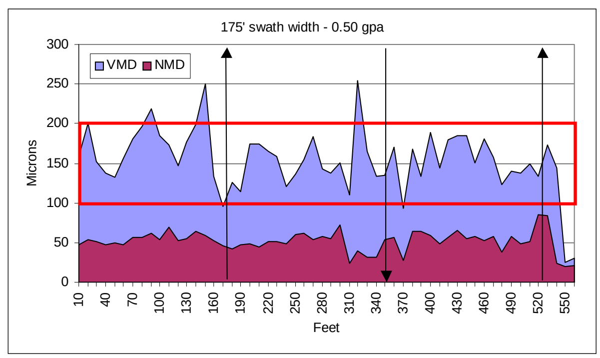

Figure 44. VMD and NMD for deposition in figure 43.

For 125 and 150 foot swath widths, deposition and droplet size met the criteria for effectiveness. However, at 175 foot, there are areas of insufficient deposition between flight lines, even with a slight cross wind. For the UH-1H (including the Bell 205 and 204), the recommended maximum swath width for 0.5 gal/ac is 150 feet.

Due to unfavorable weather conditions, the UH-1H was not evaluated at the 0.33 gal/ac application rate. However all other application aircraft have met the criteria for effective deposition for the 0.33 gal/ac rate using assigned swath width for their 0.5 gal/ac rate. It would be safe to assume that the UH-1H would likewise achieve acceptable deposit at 150 foot swath width at the 0.33 gal/ac rate.

Recommendations

Table 2 contains the maximum recommended swath widths for the aircraft and application rate indicated. To date all recommendations relate to the use of *Bacillus thuringiensis* var. *kurstaki* in control of second instar gypsy moth using rotary atomizers. If the target life stage is unknown, as is often the case in eradication projects, the swath widths should be reduced by 25 feet to increase the dose for possible third instar larvae. These maximum swath widths require that the spray aircraft be used with DGPS guidance systems to prevent low dose or skipped application that can result from excessive cross track error.

Table 2. Recommended swath widths

	Aircraft	Btk	
Fixwing		0.5 gal/ac	0.33 gal/ac
	Turbine Ag-Cat	125	125
	Air Tractor 502	150	150
	Turbo Thrush	150	150
	Dromader M-18	175	175
Rotorwing			
	206B-III (OH-58)	100	100
	205A-1 (UH-1H)	150	150
	204	150	150

Based on current results, the general observation for the maximum swath width for an aircraft for forestry application (35-50 foot release height) is approximately three times the wing span or rotor diameter.

For agricultural aerial application, with its low release height above the target surface, atomizers should not exceed 75 percent of the wing span. This prevents the vortex from lifting the spray above the aircraft and increasing drift. In forestry spraying with its higher release height, the aircraft vortex influences the spray cloud regardless of where atomizers are placed along the wing. The movement of the atomizers towards the outer wing appears to improve deposition of droplets. This may be due to the aircraft vortex accelerating the deposition of small droplets before environmental factors take hold. Atomizers placed at the outer third of the wing appear to give high levels of deposition than when evenly spaced across the wing.

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Hatfield Spraying Service - Munica, MI - Bill Hatfield and Kenny Reece (M-18)

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